Guidelines for Benefit-Cost Analysis

Introduction
The purpose of this document is to provide information about how to perform Benefit-Cost Analysis (BCA) and provide proper documentation. BCA is the method by which the future benefits of a mitigation project are determined and compared to its cost. The end result is a Benefit-Cost Ratio (BCR), which is derived from a project's total net benefits divided by its total cost. The BCR is a numerical expression of the cost-effectiveness of a project. BCRs of 1.0 or greater have more benefits than costs, and are therefore cost-effective.

This document is divided into the following sections:

A. Facilitating BCA

Although the preparation of a BCA is a technical process, FEMA has developed software, written materials, and training that simplifies the process of preparing BCAs. FEMA has a suite of BCA software for a range of major natural hazards: earthquake, fire (wildland/urban interface fires), flood (riverine, coastal A-Zone, Coastal V-Zone), Hurricane Wind (and Typhoon), and Tornado.

Sometimes there is not enough technical data available to use the BCA software mentioned above. When this happens, or for other common, smaller-scale hazards or more localized hazards, BCAs can be done with the Frequency Damage Method (i.e., the Riverine Limited Data module), which is applicable to any natural hazard as long as a relationship can be established between how often natural hazard events occur and how much damage and losses occur as a result of the event. This approach can be used for coastal storms, windstorms, freezing, mud/landslides, severe ice storms, snow, tsunami, and volcano hazards.

Applicants and Sub-Applicants must use FEMA-approved methodologies and software to demonstrate the cost-effectiveness of their projects. This will ensure that the calculations and methods are standardized, facilitating the evaluation process. Alternative BCA software may also be used, but only if the FEMA Regional Office and FEMA Headquarters approve the software.
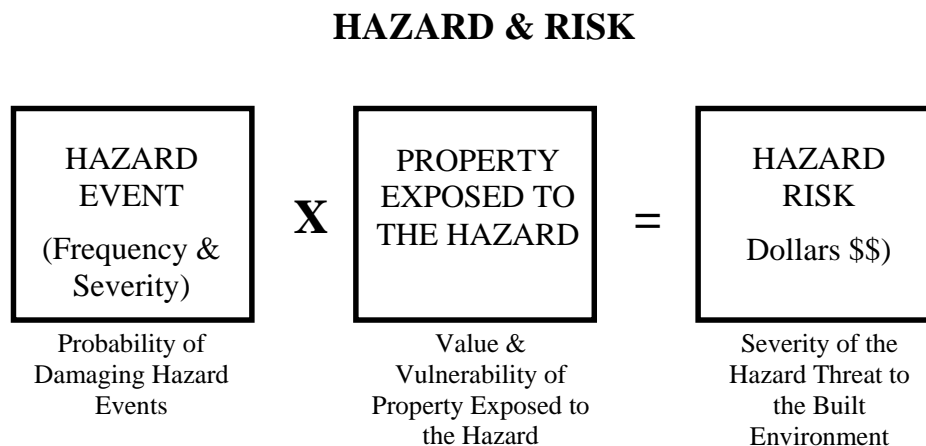
To assist applicants, FEMA has prepared the *FEMA Mitigation BCA Toolkit* CD. This CD includes all of the FEMA BCA software, technical manuals, BC training courses, Data-Documentation Templates, and other supporting documentation and guidance. The *Mitigation BCA Toolkit* CD is available free from FEMA Regional Offices or via the BC Helpline (at bchelpline@dhs.gov or toll free number at (866) 222-3580. The BC Helpline is also available to provide BCA software, technical manuals, and other BCA reference materials as well as to provide technical support for BCA.

For further technical assistance, Applicants or Sub-Applicants may contact their State Mitigation Office, the FEMA Regional Office, or the BC Helpline. FEMA and the BC Helpline provide technical assistance regarding the preparation of a BCA.

B. Identifying Cost-Effective Mitigation Projects

Applicants and Sub-Applicants are encouraged to consider the idea of "risk" when identifying and analyzing mitigation projects. Risk is simply the threat to the built environment (buildings and infrastructure) and people (casualties) expressed in terms of dollars. Risk depends both on the frequency and severity of natural hazards and on the vulnerability of the built environment and people. The highest risk situations have a combination of high hazard, high vulnerability, and high value of inventory (buildings, infrastructure, people) exposed to the hazard. This concept of risk is summarized in the figure on the next page (using flood as an example):

HAZARD & RISK

HAZARD EVENT (Frequency & Severity)	X	PROPERTY EXPOSED TO THE HAZARD	=	HAZARD RISK Dollars $$)
Probability of Damaging Hazard Events		Value & Vulnerability of Property Exposed to the Hazard		Severity of the Hazard Threat to the Built Environment

While it is generally true that high-risk situations have the highest potential benefits, the cost-effectiveness of mitigation projects also depends directly on how much they cost and how effectively the proposed activity mitigates current hazard damages. The project BCR is a *comparison* of benefits to costs. Even in situations where risk appears relatively small, such as a rural culvert washing out every year, an inexpensive mitigation project may be highly cost-effective. Projects that mitigate "big" risk are not necessarily more cost effective.

C. Technical Guidance on BCAs and Documentation

It is the Applicant and Sub-Applicant's responsibility to provide a BCA that is reasonable, credible, and well documented, using values supported within the application. A well-documented BCA means that knowledgeable subject matter experts (BC analysts) should be able to re-create the BCA from the supporting documentation and the project application without any additional explanation. Each application should include the following:

1. A narrative describing the details of the mitigation project, including the hazard (e.g., flood), the damages and losses caused, and how the mitigation project addresses the problem.

2. Documentation of the mitigation project scope and cost, including engineering cost estimates, whenever possible, and the level of protection or effectiveness of the proposed mitigation activity.

3. An electronic or paper copy of the full FEMA-approved BCA (an electronic copy is strongly encouraged). Applicants and sub-applicants must include a BCA for all properties and activities within the application.

4. Full documentation of each data element that affects the numerical BCR (see further details below). In the FEMA BCA modules, green and blue data entry cells represent entries that affect the numerical BCR. Thus, when using the FEMA software, documentation should be provided for the source and validity of each green and blue data entry cell input into the BCA software. Applicants and Sub-applicants should include a Data Documentation Template with their application to ensure documentation of all data elements.

When reviewing projects, FEMA will consider the accuracy of data, completeness of documentation, and the credibility of data sources (see Appendix I). In a nutshell, the numerical values, sources, and assumptions in a BCA must make sense and the application must verify these assumptions with supporting documentation.

The following technical guidance is intended to help Applicants and Sub-applicants provide BCAs that meet the criteria of reasonable, credible, and well documented.

1. Use the FEMA-approved BCA software and methodologies.

2. An application's project scope should be carefully explained with enough detail to understand exactly what area/buildings/people are affected by the project and what the project will do to mitigate risk. (For example, acquire and demolish 18 houses on Main Street is a clear statement of a mitigation project, when accompanied by more details within the application such as addresses, building types, square footages, building values, first floor elevations, photos, elevation certificates, appraisals, FIRMs and FIS values, etc. On the other hand, "implement measures to reduce flooding on Main Street" does not provide sufficient detail to identify either the hazard or the proposed mitigation measure.)

3. Project costs should be fully documented and supported with cost estimates from appropriate sources. For a BCA, the project cost is always the total project cost and will never be only the FEMA or federal share.

4. BCA is a net present value calculation that takes into account the useful life of mitigation projects and the time value of money. For all FEMA projects, the OMB-mandated discount rate of 7% must be used for performing BCAs. In addition, a project useful life appropriate for the specific mitigation project must be used for all BCAs. For guidance on project useful lifetimes, see the FEMA BCA Checklist, "What is a Benefit?," and other guidance on the *FEMA Mitigation BCA Toolkit* CD or contact your FEMA Regional Office or the BC Helpline.

5. Each data element of the BCA that affects the numerical BCR must be fully and carefully documented. It is recommended to use standard FEMA methodology and default data when it applies.

   a. Some data inputs may be based on national or typical data and use of such data is encouraged, when applicable to specific projects. Examples of such data include the damage data percentages in FEMA BCA software and typical values for economic impacts of road and bridge closures and loss of function of utilities (reference: *What is a Benefit?*).

   b. Many data inputs are project specific and must be documented with local data. Examples of such data include: building types, building areas, building values, first floor elevations, and values of public service, occupancy, value of timber and other project area resources, and loss of function of resources.

D. Data Documentation Guidelines

It is important to document all of the data in a BCA that affects the numerical BCR. Documentation must be complete enough so that FEMA may review the project and the accuracy of the data, using only the information in the project application. For example, a statement that "damages in the flood of April 1, 2003 totaled about $2,000,000 in Smalltown" is not sufficient. Documentation should describe where the damage occurred, with detailed breakdowns of damages to buildings, contents, infrastructure, people, etc., with enough detail to evaluate the accuracy of the damage estimate and the frequency of the event that caused the damages.

Documentation must include hazard data (flood, earthquake, etc.), building or infrastructure damage data, event frequency or magnitude data and calculations, if applicable, and information supporting economic losses and casualties.

Data from FEMA BCA software and values from FEMA guidance such as "What is a Benefit" will be accepted as credible. Data from other recognized sources such as the U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), State agencies and academic organizations have a higher degree of credibility than other sources. The application must still include supporting documentation for data inputs from these sources. Where data is purely local, supporting documentation from an engineer or other qualified source improves the credibility and robustness of documentation. Any deviations from standard procedures, methods, techniques, or guidance must be thoroughly explained and documented. In all cases, applications should include written backup for the data that is used (copies of web pages, copies of data from Flood Insurance Studies or engineering reports, etc.). Appendix I contains lists of important BCA data inputs for mitigation projects addressing the major hazards.

The *FEMA Mitigation BCA Toolkit* CD has blank hazard-specific templates for all FEMA BCA modules for use by Applicants or Sub-Applicants. The template defines the data, lists sources, and describes what documentation is appropriate. The templates should be used to ensure that data, documentation, and source credibility are adequate for FEMA's review.

E. Alternative BCA Methodology for Repetitive Flood Loss Properties

FEMA is continuing a pilot program that allows a simplified, BCA methodology for certain repetitively flooded properties insured under the National Flood Insurance Program (NFIP). These are properties that have experienced four or more insured flood losses, or have the highest severity of flooding (i.e., cumulative losses paid exceeds the property value). There are approximately 10,000 such properties, which represent about one quarter of one percent of all NFIP policies. This alternative methodology may only be applied to projects meeting the following criteria:

- Projects that address pilot NFIP repetitive loss properties on the list provided with the FY2003 –PDM-C program guidance;
- Projects that are designed to accomplish property acquisition/demolition, structure relocation or structure elevation; and
- For structural elevation projects, each structure must provide a minimum 1-foot of freeboard above the base flood elevation (BFE) or higher elevation as needed to provide 100-year flood protection plus 1-foot of freeboard. More stringent State or local requirements must be met where applicable.

For these pilot NFIP repetitive loss structures, FEMA has calculated "Potential Future Damages Avoided." For acquisition, relocation or elevation projects for properties on this list, a BCR may be calculated simply as:

Potential Future Avoided Damages / Total Project Cost = BCR.

This analysis considers only insured losses (building and contents damages). Other economic impacts (displacement costs for temporary housing and uninsured losses) are not included. If desired, a traditional BCA can be conducted to consider only benefits other than avoided building and contents damages. In this case, the total benefits are the sum of the Potential Future Avoided Damages and the additional benefits from the FEMA BCA module. The BCR may be calculated simply as:

(Potential Future Avoided Damages + Additional benefits) / Total Project Cost = BCR.

F. Unreasonable BCRs

Hazard mitigation projects with unreasonable BCRs in the 100's or 1000's are very unlikely. To have such unreasonable BCRs, the (average annual) damages would be many times the replacement value of the building. Such situations would be impossible to tolerate economically and/or the facility would have to be damaged so many times per year than repairs would be literally continuous and endless.

Based on FEMA's experience, many reported BCRs of 10 to 100 are also incorrect and are usually based on illogical or faulty data or analyses. There are a few mitigation projects where BCRs may approach or exceed 10, but these are rare and are most often where a non-structural mitigation project protects something of much higher value. Examples may include storm shutters for critical facilities in hurricane prone areas or non-structural earthquake projects that

protect very high value or critical facilities. Therefore, PDM projects submitted with extremely high BCRs will be reviewed very carefully.

Appendix I.
Technical Guidance for Data Documentation

This appendix contains additional technical information about BCA and hazard specific lists of data parameters for BCA.

As discussed in the BCA sections of the PDM Guidance, the National Benefit-Cost Review Panel will evaluate all BCAs submitted by Applicants or Sub-Applicants for three general qualities:

- Technical Accuracy
- Supporting Documentation
- Source Credibility

All input data that affect the numerical BCR must be thoroughly documented by the Applicant or Sub-Applicant in the project application. The FEMA Weighted BCR for evaluation and ranking will be determined solely on information provided in the application.

There are several evaluation criteria that apply to every mitigation project, for every type of hazard.

1. Use of FEMA-approved BCA software and methodologies is required. Non-FEMA software may be used only if FEMA Region and FEMA Headquarters Mitigation staffs approve the software in advance in writing. The exception for FEMA-approved BCA software is that the Flood Very Limited Data (VLD) Module may not be used to demonstrate cost-effectiveness for a project, only to screen projects as possibly cost-effective.

2. The OMB-mandated discount rate of 7% must be used for all BCAs.

3. Mitigation project scope must be explained in sufficient detail so that evaluators fully understand what the hazard (e.g. flood, earthquake, ice, wind, wildfire, etc.) is, what damages and losses it is causing, how the project works to mitigate the identified problems, and how effective (i.e. the level of protection provided) the project will be in reducing future damages and losses. Acquisition/relocation is the only common mitigation project that is 100% effective in avoiding future damages and losses and where the National Benefit-Cost Review Panel should see no damages after mitigation in the applicant's submitted BCAs. For all other types of projects, documentation must be provided to determine how effective the project will be in reducing damages after mitigation at various levels of hazard severity or frequency.

4. Project costs must be fully documented and supported with engineering cost estimates, whenever possible. For BCAs, the project cost is always the total project cost, not the FEMA or Federal share. If annual maintenance costs are necessary for a mitigation project to be effective, such costs must be included and documented.

5. Project useful life must be consistent with FEMA guidance and practice. See the BCA Checklist, "What is a Benefit?" guidance, and the technical manuals for the FEMA BCA

software or consult FEMA Regional Offices or the BC Helpline for guidance on useful life for specific mitigation projects.

6. The benefits of avoiding or reducing casualties may be significant for some types of projects. However, for many common types of mitigation projects, such as flood projects other than flash flooding or dam/levee failure, life-safety benefits are often negligible or non-existent. Any BCA that claims life-safety benefits must carefully and thoroughly document the <u>direct</u> connection between the proposed mitigation project and reductions in future deaths and injuries. For FEMA statistical values for injuries and deaths, see "What is a Benefit?" guidance. The 2003 values for life-safety found in "What is a Benefit?" may be inflated to 2004 values.

7. Many of the FEMA BCA modules contain typical or default data. Use of such data will be accepted as long as the data are applicable to the specific mitigation project. However, Applicants and Sub-Applicants must understand the applicability of the typical or default data. For example, use of residential depth-damage percentages for infrastructure or a wastewater treatment plant, or use of seismic damage percentages for non-structural building retrofits or infrastructure projects would be incorrect, and would negatively impact the review and evaluation process.

The number and types of data inputs for BCA vary depending on the hazard being addressed, the type of mitigation project and other factors. The Common Data Inputs for BCA section of this appendix summarize the major data inputs required for common mitigation projects for the most common hazards.

The relative importance of each data input on the BCR varies significantly from project to project. For example, life-safety benefits (avoided deaths and injuries) may be very important for some types of mitigation projects (e.g., seismic structural retrofits of buildings) but may be negligible or non-existent for other types of projects. Data inputs are listed in approximate order of importance, but Applicants and Sub-Applicants must realize that the actual order of importance varies from project to project.

For hazards that are addressed by less-common mitigation projects (Example: Utility protective measures for ice storms), the specific data inputs required for BCA may vary from those in the Common Data Inputs for BCA section of this attachment. In such cases, Applicants and Sub-Applicants are responsible for ensuring that all data inputs for their specific mitigation projects are thoroughly documented, regardless of whether the data inputs are included on the following data lists. The Data Documentation Templates found on the *FEMA Mitigation BCA Toolkit* will help ensure that Applicants and Sub-Applicants document all data inputs.

Many of the data items listed below have specific meaning within the BCA process. Applicants, Sub-Applicants and BC analysts are encouraged to obtain technical materials, take training when available, and contact the BC Helpline at bchelpline@dhs.gov or toll-free by phone at (866) 222-3580) or the FEMA Regional Offices if they need assistance with understanding these data terms or with any other aspects of BCA.

Common Data Inputs for BCA

Frequency-Damage Analysis Methodology (Flood and Most Other Hazards)

The frequency-damage module (Riverine Limited Data Module) was designed for BCAs of flood mitigation projects for locations without quantitative flood hazard data (i.e., outside of mapped floodplains) and/or without first floor elevation data. This module can also be used for other hazards (e.g., ice storms, snow, windstorms) for which frequency-damage relationships can be derived from historical damage data and/or engineering judgment.

The frequency damage method should never be used for BCA of seismic, hurricane wind, wildfire, or tornado/hurricane shelter mitigation projects. For these hazards, national quantitative hazard data exists and, thus, much more accurate BCAs can be conducted using the hazard specific BCA software for earthquakes, hurricane wind, wildfire, or tornado/hurricane shelters. Common data inputs include:

1. Documentation of event frequency
2. Pre-mitigation damages and losses in high frequency events (1 to 10-year recurrence interval)
3. Pre-mitigation damages and losses in moderate frequency events (10 to 50-year recurrence interval)
4. Pre-mitigation damages and losses in low frequency events (>50 year recurrence interval)
5. Effectiveness of mitigation project → to what level of event does the project avoid or reduce future damages?
6. Project Useful Life
7. All pre-mitigation damages or losses with high value
8. All estimates of deaths and injuries
9. Functional downtime and value of loss of service

Engineering Data Analysis Methodology
Flood Hazards (Riverine, Coastal A-Zone and Coastal V-Zone Full Data Modules)

The engineering data analysis method uses quantitative data to determine the frequency and severity of flood events, and engineering data to calculate damages and losses before and after mitigation. Common data inputs include:

1. Finished floor elevation
2. Flood elevation data (typically 10, 50, 100 and 500-year) for riverine flooding. When using the Coastal V-Zone Module, the stillwater flood elevations and the wave height (100-year only) are required.
3. Flood discharge data (Riverine only)
4. Project Useful Life
5. Building type
6. Building replacement value
7. Depth-damage functions (if not FEMA software typical values)
8. Building damage percentage resulting in demolition
9. Contents replacement value

10. Functional downtime and value of loss of service (especially if large fraction of benefits)
11. Continuity premium for loss of public services (if used)
12. Displacement times and costs (if not FEMA typical values)
13. Building area
14. Net business income (if commercial property)

Engineering Data Analysis Methodology
Seismic Hazards (Seismic Full Data Module: Structural Mitigation Projects for Buildings)

Note: Several important aspects of the Seismic Full Data BCA module are outdated. See the *Mitigation BCA Toolkit* for essential updates for seismic hazard data, seismic damage functions, casualty rates and other critical inputs for BCA. **Do not use the Seismic Full Data Module without incorporating these updates.** Common data inputs include:

1. Seismic hazard data (see *Mitigation BCA Toolkit*)
2. Soil type (see *Mitigation BCA Toolkit*)
3. Building structural system type
4. Building area
5. Building replacement value
6. Project Useful Life
7. Seismic-damage functions (if not FEMA software typical values – see *Mitigation BCA Toolkit*)
8. Building damage percentage resulting in demolition
9. Building occupancy
10. Casualty rate estimates (see *Mitigation BCA Toolkit*)
11. Contents replacement value
12. Functional downtime and value of loss of service (especially if large fraction of benefits)
13. Continuity premium for loss of public services (if used)
14. Displacement times (if not FEMA typical values) and costs
15. Net business income (if commercial property)

The Seismic Full Data module should not be used for non-structural mitigation projects such as bracing or anchoring contents or equipment, or for projects addressing non-structural building elements such as ceilings or windows. For such projects, the Non-Structural Seismic Module should be used (see *Mitigation BCA Toolkit*). The Non-Structural module contains BCA templates and typical data for many types of common non-structural projects. The specific data required for the BCA vary from project to project, although data documentation requirements are generally similar to those for buildings. For non-structural projects, documentation should be provided for all data entries applicable to the specific type of mitigation project.

Engineering Data Analysis Methodology
Hurricane Wind Hazards (Hurricane Wind Full Data Module)

1. Wind hazard data
2. Distance inland

3. Building type
4. Building area
5. Project Useful Life
6. Building replacement value
7. Wind-damage functions (if not FEMA software typical values)
8. Effectiveness of mitigation project in reducing damages
9. Building damage percentage resulting in demolition
10. Contents replacement value
11. Functional downtime and value of loss of service (especially if large fraction of benefits)
12. Continuity premium for loss of public services (if used)
13. Displacement times (if not FEMA typical values) and costs
14. Net business income (if commercial property)

Wildland Urban Interface Fire Mitigation Projects (Wildland Fire BCA Module)

1. Fire hazard data – standard method
   a. Sample area of similar fire hazard
   b. Total acres burned in sample area over time period
   c. Number of years in time period
2. Fire hazard data – user-defined burn interval – full documentation is extremely important for use of user-defined burn interval
3. Damages and Losses Before Mitigation: All of these data must be ONLY for the specific geographic area directly affected by the mitigation project
   a. Building value
   b. Contents value
   c. Infrastructure
   d. Timber value
   e. Fire suppression costs
   f. Other costs or damages related to the wildfire hazard, such as debris or mud flows
   g. Number of residents
   h. Annual death rate per 1,000,000
4. Effectiveness of mitigation measure (percent reduction in damages and losses) – full documentation is extremely important to justify the value entered in the BCA. Consultation with fire service professionals is highly recommended.
5. Project Useful Life

Standard Analysis Methodology
Tornado Hazards

1. Building type
2. Shelter floor area
3. Shelter design wind speed
4. Occupancy [numbers vs. time]
5. Project Useful Life
6. Injury and mortality percentages [curves], if default not used
7. Building dimensions

8. Building damage percentage resulting in demolition
9. Shelter floor area

Appendix II
FEMA BCA Checklist
Last Updated on July 29, 2004

1.0   INTRODUCTION

FEMA will review the benefit-cost analyses (BCAs) that are required for all proposed mitigation projects submitted under the FEMA grant programs. The review will determine whether the information provided in the application demonstrates:

1. The BCA components are credible and well documented.
2. The BCA is prepared in accordance with accepted FEMA BCA practices.
3. The project is cost-effective.

A prospective applicant or sub-applicant should use this checklist as a guide for preparing a complete, well-documented grant application. The information that follows is grouped by category and meant to help applicants and sub-applicants submit a complete and technically supported BCA that can be properly reviewed for the criteria listed above.

Notes:
1. Technical assistance for BCA questions can be obtained by calling toll-free to the FEMA BCA Helpline at 1-**866-222-3580** or via e-mail at: **bchelpline@dhs.gov**. Responses are provided within 48 business hours. The *FEMA Mitigation BCA Toolkit* CD can be ordered through the Helpline or e-mail address.

2. All technical support data (reports, maps, calculations, design plans, engineering drawings, etc.) from previous applications should be resubmitted with all new applications.

3. All applications should include the appropriate FEMA Data Documentation Template (or DDT, found on the *FEMA 2003 Mitigation BCA Toolkit* CD) as a self-check for and verification of documentation and credibility of the data provided in support of the BCA.

2.0   BCA DATA REQUIREMENTS

2.1   General Data Requirements

2.1.1   All BCA data entries (other than FEMA standard or default values) MUST be documented in the project description or Project Scope of Work (SOW) that accompanies the grant application. The documentation should include:

(a) The source of the data (title, author, date).

(b) A full description of the data, the project, and how the proposed measure will mitigate against future damages.

(c) The data MUST be from a credible source. Credible sources include federal, state, county, regional, local government agencies or qualified professionals such as licensed architects, engineers, and surveyors. Credible sources will vary depending on the data item.

(d) Data obtained from sources other than those in (c) above MUST include a complete discussion of the methodology used and how it was applied for the proposed mitigation project to establish data credibility.

2.1.2   Complete copies should be provided for all reports, technical bulletins, engineering analyses, or guidance documents cited in the application as technical support data.

2.1.3   Detailed project costs MUST be broken out and certified with a signature for all major construction components, including, but not limited to, materials, labor, excavation, soil brought to or removed from the site, concrete, hazardous materials testing and disposal, equipment such as pumps and site restoration after construction is complete.

2.1.4   The FEMA required Discount Rate of 7% MUST be used in all BCA module runs.

2.1.5   The Base Year of Costs for all damages used in the BCA MUST be identified in the BCA module run and be consistent with any technical support data provided with the application.

2.1.6   The Hazard (flood, wind, seismic, etc.), Risk, and Frequency of the hazard MUST be provided and supported based on historical information from damage curves or previous disasters. This information MUST also be consistent between the application, BCA module runs, and technical data or reports submitted in support of the application.

2.1.7   Project Useful Life (i.e., the length of time that the mitigation project will provide protection) MUST be consistent with guidance provided in the FEMA How To Determine Cost-Effectiveness of Hazard Mitigation Projects (Interim Edition, December 1996) document. This document is also known as the FEMA Yellow Book (due to the color of the cover) and is included on the *FEMA Mitigation BCA Toolkit* CD.

2.1.8   The Level of Protection (also known as the effectiveness of a mitigation project) MUST be specified for the hazard identified in the application. Examples are protection "up to 50-year flood" for a flood mitigation project or "up to a wind speed of 120 mph" for a tornado or hurricane shelter project.

2.1.9 Data provided in support of daily traffic counts for damages associated with traffic delays or detours should be signed by a PE, a planner, or a County DOT manager with signature authority. Damages associated with traffic delays or detours MUST be consistent with guidance provided in Section 7 of the *FEMA What Is A Benefit?* document (which is included on the *FEMA Mitigation BCA Toolkit* CD).

2.1.10 The values for minor injuries, major injuries, and casualties that exceed the FEMA standard values used in the Limited Data (only for flash floods and some non-flood hazards), Seismic, Tornado, and Wildfire modules MUST be fully documented and from credible sources.

2.1.11 The Very Limited Data (VLD) BCA module can only be used for screening purposes and cannot be used to support cost-effectiveness of a grant application.

2.1.12 The FEMA Region and FEMA Headquarters Mitigation staffs MUST approve alternative BCA software in writing prior to submittal with an application.

2.1.13 Paper copies of BCA module runs require the same level of documentation as electronic copies of the module runs.

2.2 BCA Damage Data

2.2.1 The data should be well documented for each event that resulted in damages. The data should also be consistent with the type of mitigation project proposed (i.e., flood damage data should be provided in support of a proposed flood mitigation project). If damages were recorded for multiple events, the estimated frequency and the associated damages MUST be documented and provided for each event to support the damage analyses in the BCA.

2.2.2 Data used in place of FEMA standard or default values in the BCA modules MUST be documented and include justification of why it is more appropriate than the FEMA values. Even minor changes in data, say a 2% increase for each foot of flood depth in the percent damage in a depth-damage curve, will be considered incorrect data if it is not fully documented or it lacks a justification for its use.

2.2.3 When using the Wildfire module, the "burn data" (sample area size, acres burned, type of fuel, burn recurrence interval, timber value, fire suppression costs, mitigation project life, etc.) MUST be provided, documented, and obtained from a credible source.

Note: Specific BCA Damage Data requirements are organized by hazard type (flood, seismic, wind, etc.) and discussed in more detail in the Data Documentation Templates found on the *FEMA Mitigation BCA Toolkit* CD.

2.3   BCA Benefits Data

Because benefits are considered to be damages prevented, the applicant MUST demonstrate the following:

2.3.1   All benefits claimed MUST be fully documented and the sources cited in the applicant's project overview.

2.3.2   The damages prevented MUST be consistent with the damage history provided in 2.2.1 above and with the proposed level of protection.

2.3.3   The applicant MUST demonstrate that the proposed mitigation measure protects up to the proposed level of protection. For floods, this could be shown by elevation data, such as: "the lowest height of an elevated structure being 0.5 feet above the elevation of a 25-year flood".

2.3.4   The applicant should identify and quantify residual damages. These refer to expected future damages that remain after a mitigation project is in place. Some types of mitigation projects, such as elevation or floodproofing, do not eliminate all flood damages. A lack of a discussion on residual damages or failure to include appropriate residual damages in the BCA may result in the BCA being considered incomplete.

2.3.5   When using the Limited Data module, the applicant may not extrapolate damages from documented longer return period (lower frequency) events to damages with unknown, shorter return periods (higher frequency) events. For example, do not extrapolate damages from a known 20-year event down to a 2-, 5-, or 10-year event. This is not an approved methodology for determining benefits at higher frequency events.

2.3.6   The Loss of Function (value of services that can not be provided due to damage) and the Functional Downtime (length of time in days that the loss of function is in effect) MUST be reasonable, defensible, and documented.

2.3.7   The Displacement Costs (costs occurred for moving to temporary quarters while repairs are made) and Displacement Time (the length of time in days that the displacement costs are incurred) MUST be reasonable and documented.

2.3.8   A Continuity Premium, which is a multiplier on the value of services to account for critical services, can only be used for services that are in immediate need after a disaster, such as police, fire, and emergency services.

Note: Specific BCA Benefits Data requirements are organized by hazard type (flood, seismic, wind, etc.) and discussed in more detail in the Data Documentation Templates found on the *FEMA Mitigation BCA Toolkit* CD.

2.4   BCA Building Data

2.4.1   All mitigation projects involving the elevation of or protection for residential or commercial buildings should include completed FEMA Elevation Certificates for each building in the application. The Elevation Certificates should be signed, sealed, and dated by an engineer or surveyor licensed to practice in the state where the mitigation project is to be built.

2.4.2   Data for building type, number of stories, and total size (in square feet and equal to the number of stories multiplied by the square footage for each story) should be included in the application in accordance with the requirements of the BCA module for a specific hazard. Photocopies of tax records, hard copies of photographs, or electronic files of images ("jpg" format for images) are sufficient to meet this data requirement.

2.4.3   The method and source for determining the building replacement value (BRV) unit cost or the total BRV MUST be provided with the application.

2.4.4   When using assessed tax values as the basis for a BRV, the multiplier and method used to develop the BRV MUST be documented and from a credible source such as the County Tax Assessor.

2.4.5   The amount of damage (as a percent of the pre-damage structure value) that will result in demolition of the structure MUST be provided in the BCA. The application MUST contain documentation to support the use of a value if different from the FEMA standard value of 50%.

2.4.6   All claims for contents values in excess of the FEMA standard value of 30% of the pre-damage building value MUST be fully documented, including a summarized list of content items and the estimated or insured value of each item.

2.4.7   The mitigation project site location in "miles inland" MUST be identified and documented when the Hurricane module is used.

2.4.8   For occupancy values, note that the Tornado module requires the design occupancy for the proposed shelter, while the two Seismic modules require the average daily occupancy (including weekends and holidays) over the course of one year.

2.4.9   Mitigation projects using the Tornado BCA module MUST also include:

- longest length of the building
- longest width of the building
- square footage of the proposed shelter area
- shelter construction type (i.e., construction materials)
- site location referenced by county and state

3.0 PROBLEM DESCRIPTION AND PROPOSED SOLUTION

3.1 General Questions

3.1.1 Has the hazard been properly identified for the project site?

3.1.2 Has the risk to the structure been described and clearly documented?

3.1.3 Does the application describe all hazards for which mitigation is proposed?

3.1.4 Is the BCA fully documented and accompanied by technical support data?

3.1.5 Is there any residual risk to the facility after the proposed mitigation is implemented?

The following represents examples of two common project types (Flood Control Project and Structural Elevation) and the relevant information to include with the application

3.2 Riverine Flood Control Project

3.2.1 Identify the source of the flood hazard data:

(a) A copy of the Flood Insurance Study (FIS), marked up to show the project location, should be submitted with the application. These data should include copies of the Flood Insurance Rate Map (FIRM) (title block and map) and the appropriate flood profile from the FIS report.

(b) If flood data from another agency is used, provide the agency name, the report title, the name of the watercourse studied, and the date of the report. (A photocopy of the report cover may be submitted to provide some of this information).

(c) If flood data was developed by an engineer or hydrologist for the application, provide the name, registration number (for an engineer), date of the analyses, and methodology used (hand calculations or a specific computer model such as TR-20 or HEC-RAS)

3.2.2 Provide a Scope of Work (SOW) for the project that is consistent with the information provided for the engineering review.

3.2.3 Describe the existing flood conditions for the project.

3.2.4 Briefly describe how the proposed mitigation project will provide protection for the facility.

3.2.5 Identify the proposed level of flood protection for the mitigation project (i.e., "The project will protect the pump station for up to a 50-year flood event on Amberly Creek."). This value MUST be included in the project application to verify the effectiveness of the mitigation project.

3.2.6 Provide a detailed work schedule and breakdown of the complete project costs without regards to whom will pay the costs (FEMA or another state or local funding source).

3.3 Projects Based on the Limited Data Module

3.3.1 Verify that use of the Limited Data Module is appropriate for the proposed mitigation project. The Limited Data Module is required when one or more of the following conditions are met:

(a) Flood mitigation projects where Flood Insurance Study (FIS) or comparable documented flood data from another agency, engineer or hydrologist is not available.

(b) Flood mitigation projects where the First Floor Elevation (FFE) of the structure is not documented.

(c) Flood mitigation projects related to flash flooding, alluvial fan flooding, debris or mudflows, and landslides.

(d) Flood, wind or earthquake hazard mitigation projects for non-building facilities such as culverts, roads, bridges, and utility systems.

3.3.2 Provide a Scope of Work (SOW) for the project that is consistent with the information provided for the engineering review.

3.3.3 Describe the existing flood conditions for the project.

3.3.4 Briefly describe how the proposed mitigation project will provide protection for the facility.

3.3.5 Provide detailed documentation of damages at the project site for two or more hazard events of known frequency. The following requirements must be met when compiling hazard event data:

(a) For two or more events of the similar frequencies, use the average damage for the events with the average frequency. Do not combine two or more events with widely varying frequencies.

(b) Estimates of damage between events of two known frequencies may be permitted if the estimates are reasonable and documented. However, estimates of damage based on extrapolation from events of two known frequencies are not recommended. Extrapolation of damages to more frequent events from one or more known less frequent events is not permitted.

(c) Flood mitigation projects related to flash flooding, alluvial fan flooding, debris or mudflows, and landslides.

(d) Flood, wind or earthquake hazard mitigation projects for non-building facilities such as culverts, roads, bridges, and utility systems

3.4   Coastal Flood Protection Projects

The FEMA Coastal A- or V-Zone BCA Modules should be used for evaluating and determining the cost-effectiveness of coastal flood protection projects. Data for coastal projects are based on information similar to that utilized in the FEMA Riverine Full Data Module and the requirements described in Section 2.0. The text below discusses the data differences between the two modules.

Coastal A-Zone Mitigation Projects

3.4.1   The Flood Hazard Data is based on information provided in the "Summary of Stillwater Elevation Tables" from a FEMA Flood Insurance Study (FIS). This table provides the stillwater elevations for the 10-, 50-, 100- and 500-year flood events.

Coastal V-Zone Mitigation Projects

3.4.2   The Building Data for a building in a V-Zone considers whether the building has an obstruction (i.e. wall or structural member) below the elevation of the lowest floor or horizontal member.

3.4.3   For Building Data, the elevation of the lowest floor is based on the lowest horizontal structural member.

3.4.4   Similar to the Coastal A-Zone Flood Hazard Data, the Coastal V-Zone data is based on information provided in the "Summary of Stillwater Elevation Tables" from the FIS. This table provides the stillwater elevations for 10, 50, 100 and 500-year flood events. Based on this data, the BCA module will automatically compute the elevations with the wave height. Depending on the exact location of the project, the module allows for a user-entered elevation for the 100-year flood, which may be determined from the Flood Insurance Rate Map (FIRM).

3.5   Hurricane Wind Projects

3.5.1   The Building Type is one of the most critical data elements for determining an accurate BCR. This should be based on design drawings and determined by a building official, a registered professional engineer or a licensed architect.

3.5.2   The Building Site (in miles inland from the coast) should be identified on a map submitted with the application. The accuracy of the BCR is based in part on the accuracy of the location of the building from the coast.

3.5.3   The Wind Hazard Data requires the wind speed at the coast and at a location 125 miles inland for the 10-, 25-, 50-, 100-, and 2000-year events. This data is found on

FEMA Mitigation BCA Toolkit CD and was prepared by the Coastal Engineering Research Center, titled "Coastal Engineering Technical Note", CETN-I-26 12/85.

3.5.4   A detailed project description should be provided to demonstrate Project Effectiveness. In addition to the design wind speeds, this information should also identify which building components will be replaced or retrofitted as part of the project. The design wind speeds of the <u>existing</u> building and the mitigation project are used to determine the appropriate *percent damage* in the Wind Damage Functions of the BCA module.

3.3   Tornado Mitigation Project

3.6.1   Verify that the Tornado BCA module has been installed properly (complete installation instructions are on the *FEMA Mitigation BCA Toolkit* CD).

  (a) For Windows 95 and 98, follow the directions that appear on the screen for installation.

  (b) For Windows 2000, ME, XP, and XT, follow the instructions until a prompt states that there is a "version conflict". Then follow the instructions on the *FEMA Mitigation BCA Toolkit* CD to finish the installation.

3.6.2   The Building Information, Tornado Hazard Information, and Mitigation Project Information sections of the module are extremely important to developing a good BCA that is based on appropriate and defensible data. The data entries must be complete in each section to develop an accurate BCA.

3.6.3   Tornado Building Information section:

  (a) The project state and county are necessary for running the Tornado module properly.

  (b) The longest structure length and width are keys for determining the likelihood of the structure being impacted by a tornado.

  (c) The proposed shelter area (in square feet), shelter construction type, and shelter occupancy are important in determining the performance effectiveness and cost-effectiveness of the mitigation measure.

3.6.4   Tornado Hazard Information section

  (a) The module database must have a sufficient number of past tornadoes to determine the probability of tornado occurrence in a selected county. Because it is unlikely that a single county will have a sufficient number of tornadoes for meaningful statistics, the sample area of counties must be large enough to be representative of the hazard. The module contains a database with data for all counties.

3.6.5   Mitigation Project Information section

(a) For design wind speeds other than those found in FEMA 361 (fig. 2-2) or ASCE-7-98, the application will need to include documentation on the source of the data and justification of why the design wind speeds used are more appropriate than the standard sources.

(b) If FEMA default values for injuries or deaths at various wind speeds are over-ridden, the application will need to include documentation on the source of the data and justification of why the data is more appropriate than the default data.

3.7   Seismic Mitigation Project

3.7.1   A seismic structural engineer should be consulted for designing structural or non-structural seismic mitigation projects.

3.7.2   Verify that the data obtained from the BCA Earthquake software patches is entered correctly into the Earthquake Full Data Module

3.7.3   Verify that the correct FEMA seismic BCA module and associated software patches are used for evaluating the proposed mitigation project. The BCA seismic modules and the software patches are contained on the *FEMA Mitigation BCA Toolkit* CD.

(a) For Building Structural Retrofit Projects, use the Earthquake Full Data Module and the associated software patches to correctly update data for the seismic hazard, soil/rock conditions, damage functions (fragility curves) and casualty rate estimates. If the software patches are not used, the user-entered values for the alternate seismic hazard analysis should be supported by documentation.

(b) For common, Non-Structural Seismic Retrofit Mitigation Projects, use the Limited Data Module and the software patches to obtain the latest data for the seismic hazard and soil/rock conditions.

(c) The Earthquake Limited Data Module should only be used for selected (non-building) seismic hazard mitigation projects located in the State of California. This <u>module does not contain</u> built-in damage functions. It is intended only for experienced users who can independently determining the appropriate damage functions. The seismic hazard data format was designed specifically for use in California.

Note: Although the module names are similar, Items 3.4.2 (b) and (c) above refer to two different BCA modules.

3.7.4   The Earthquake Full Data Module requires the software patches to properly update the data used in the module sections discussed below. Failure to use the patches in the Full Data Module will typically result in an underestimation of benefits and low BCR values.

(a) In the Seismic Hazard section, replace the expected annual number of earthquakes computed by the module with user-entered estimates obtained from the BCA Earthquake Seismic Hazard Calculator and BCA Earthquake Hazard Adjustment for Soil-Rock Type. Projects located in Washington State can use the BCA Earthquake Washington State Seismic Hazard Data module instead of the seismic hazard and soil-rock adjustment software patches. Documentation should be provided to support the use of values obtained from a seismic hazard analysis.

(b) Replace the Building Seismic Damage Function (SDF) and the Building Casualty Rates for the before and after-mitigation scenarios with user-entered estimates obtained from the BCA Earthquake Fragility Curve Calculator based on the building type, number of stories, and the before- and after-mitigation building code design requirements. The applicant should include documentation to support the use of fragility curves other than the HAZUS curves included in the Fragility Curve Calculator.

3.7.5 The Limited Data Module for Non-Structural Seismic Hazard Mitigation Projects allows users to evaluate mitigation projects for common non-structural items including:

- Equipment
- Cable Elevators
- Contents
- Chimneys
- Ductwork
- Fire Sprinklers
- Electrical Junction Boxes

- Generators
- HVAC Fans
- Library Shelves
- Parapet Walls
- Storage Racks
- Suspended Ceilings

The following issues must be considered when using this module:

(a) Verify and document values related to building occupancy rates, estimated dollar value of casualties, and value of lost services per day. This is critical because most benefits for non-structural mitigation projects are due to avoided casualties and the avoided loss of function.

(b) In the Seismic Hazard section, input the expected annual number of earthquakes with values obtained from the BCA Earthquake Seismic Hazard Calculator and BCA Earthquake Hazard Adjustment for Soil-Rock Type. Projects located in Washington State can use the BCA Earthquake Washington State Seismic Hazard Data module. Include documentation to support user-entered values not derived through the software patches.

4.0   COMMON SHORTCOMINGS

4.1   Incomplete documentation.

4.2   Inconsistencies between data in the application, the BCA module runs, and reports and other data sources submitted as technical support data.

4.3   Lack of technical support data (especially reports referenced in the application but not provided).

4.4   Lack of a detailed cost breakdown for mitigation project costs.

4.5   Use of project costs that do not include all project items, such as costs for administration, design and engineering, property acquisition, etc.

4.6   Use of a discount rate other than the FEMA standard of 7%.

4.7   Lack of documentation for Loss of Function or Functional Downtime

4.8   Use of base year costs or damages without updating to current year.

4.9   Use of undocumented traffic counts and detour times for traffic delay data.

4.10   Use of hourly traffic delay costs that are higher than the FEMA standard of $32.23/hour/vehicle. Also, it is incorrect to add a continuity premium to the standard traffic delay value because the value already accounts for emergency traffic.

4.11   Overriding the FEMA default values without providing documentation or justification.

4.12   Lack of information or data on building type, size, number of stories, and value.

4.13   Lack of documentation and identified data sources for First Floor Elevation (FFE) data.

4.14   Use of incorrect project useful life. Many applicants incorrectly assume that all projects have a useful life of 100-years. Some examples of appropriate project life estimates include:

Acquisition/relocation	100 Years
Residential elevation	30 years
Commercial/Office elevation	30 years
Infrastructure	10 – 50 years (depending on type

	of infrastructure)
Equipment (such as Generators, storm shutters, etc.)	5 – 30 years (depending on type of equipment)
Vegetation management	5 – 15 years (depending on the maintenance plan and schedule)

4.15 Lack of documentation, basis, and multiplier for determining a building replacement value (BRV) based on tax data.

4.16 Poor documentation or credibility regarding the frequency-damage relationship when using the Limited Data module.

4.17 Using or extrapolating damages or benefits for higher or lower flood frequencies in the Limited Data module.

4.18 Using the Very Limited Data (VLD) module to determine a BCR when it should be used only for screening purposes.